DOCUMENT RESUME

ED 185 946 HE 012 666

AUTHOR Schuytema, Eunice C.; And Others
TITLE Development and Evaluation of Problem-Solving Skills in Microbiology.
PUB DATE Apr 80
NOTE 17p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April 1980)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; Course Evaluation; Higher Education; *Laboratory Training; *Medical Students; *Microbiology; Predictor Variables; *Problem Solving

ABSTRACT

A problem solving, laboratory experience was devised in which first-year medical students were given a case description and then required to make judgments about what microbiology specimens should be collected and to analyze the results of laboratory tests in terms of implications for patient care. Over a four-year period revisions were made in the instruction and evaluation methods of the microbiology course. The three design variables which were included in the study were number of laboratory hours spent on problem solving techniques, class credit awarded for completion of laboratory activities, and exposure to problem solving examination items. Variations in these instructional methods were considered across the four years. Two of the variables were eventually dropped from the statistical analysis because of multicollinearity. A regression equation predicted student achievement on problem solving test items from number of hours spent in problem solving laboratory exercises. It is concluded that hours spent in problem solving laboratories had the strongest relationship with problem solving achievement, although test item exposure and student accountability also had an effect. (Author/SW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED185946

Development and Evaluation of Problem-Solving Skills in Microbiology

E. SCHUYTEMA, R. CARTER, G. GRAY, B. ESHLER
Rush Medical College/Rush University

Eunice C. Schuytema, Ph.D.
524D Academic Facility
600 S. Paulina Street
Chicago, Illinois 60612

ABSTRACT

A problem-solving, laboratory experience was devised in which first year medical students were given a case description and then required to make judgements about what microbiology specimens should be collected and to analyze the results of laboratory tests in terms of implications for patient care. Over a four-year period revisions were made in the instruction and evaluation methods of the microbiology course. The three design variables which were included in the study were number of laboratory hours spent on problem solving techniques, class credit awarded for completion of laboratory activities, and exposure to problem solving examination items. Variations in these instructional methods were considered across the four years. Two of the variables were eventually dropped from the statistical analysis because of multicollinearity. A regression equation to predict student achievement on problem solving test items from number of hours spent in problem solving laboratory exercises produced an R^2 of .89. The conclusion reached is that hours spent in problem solving laboratories had the strongest relationship with problem solving achievement, though test item exposure and student accountability also had an effect.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Eunice C. Schuytema

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

HE012 666

Development and Evaluation of Problem-Solving Skills in Microbiology

E. SCHUYTEMA, R. CARTER, G. GRAY, B. ESHLER
Rush Medical College/Rush University

Eunice C. Schuytema, Ph.D.
524 D Academic Facility
600 S. Paulina Street
Chicago, Illinois 60612

Introduction

The challenge of designing a microbiology course to help students learn to use facts to solve clinically related problems was addressed over a four year period. This focus departs radically from the goal of traditional instruction in microbiology where the emphasis is on helping students master microbiological facts. While this is a worthy goal, the relevance of microbiology to specific types of physician behaviors is not typically addressed.

Gabridge (1974) cited a test administered by the American Heart Association Committee on Rheumatic Fever, in which it was discovered that two thirds of the interns queried could not identify the major determinant of virulence of Streptococcus, and half thought that the major enzyme produced by Staphylococcus was also produced by Streptococcus. In another quiz administered by the National Commission on Veneral Disease, three quarters of new physicians failed a test on the basic biology of VD. It would appear that retention of microbiological information for subsequent application is inadequate under traditional instructional conditions.

Gratzek (1973) stated that, "an important objective in veterinary medicine is to train students to render scientifically based judgements concerning all aspects of infectious diseases of animals." Based on a review of the literature, it does not appear that this type of objective is considered to be of primary importance by most microbiologists who teach medical students. In a curriculum survey reported by Myrvik et al (1976) problem solving and case history examinations were listed among thirty-five "helpful innovations" in the survey, and one of ten trends reported was that "laboratory

experimentation and examinations are being presented as problem-solving situations"; however, no additional information was provided. Indeed, the authors have been unable to locate any published accounts of problem-solving curricula in medical microbiology.

Method

The microbiology course at Rush originally included fifty contact hours, of which fourty-four were lecture and six were laboratory demonstration. The mean number of hours for microbiology instruction in United States medical schools was approximately 148 (which includes 30 hours or so of immunology). In order to assure that students were exposed to the requisite microbiology content, a complete set of learning objectives and a comprehensive syllabus were developed.

During the spring of 1976, the following objective was part of the Rush Medical College microbiology course:

> Given a description of a patient, the student will make judgements about what specimens should be collected and will analyze the results of laboratory tests in terms of implications for patient care.

Progress toward this goal over a four year period was evaluated by problem-solving items based on real and simulated case material. (See illustration I.) Changes in the microbiology course followed a four-stage process. Each year the course was offered modifications were made based on student performance data and on faculty and student evaluations of the course. The following section describes the four administrations of the course and the associated findings from evaluation activities.

In the first year forty-four hours of lecture and six hours of laboratory were presented. During the six hours of demonstration laboratory, students

learned to do a gram stain, to recognize various types of organisms on differential and selective media, and to observe the results of biochemical tests. During the first year of the study, this traditional approach to instruction was employed. The only aspect of the course that changed in 1976 was the addition of test items based on patient data and laboratory reports. Some of these tests items involved recall of microbiological facts; other questions required application of facts to clinical problems. No attempts was made to model the behavior students would be required to use on the test since it was assumed that they would be able to apply what they had learned without additional instruction. This assumption proved false. Performance on the application and problem-solving items was much worse than anticipated. The class average on recall questions was a raw score of 73 out of 119 (61%). The average score for problem-solving was only 2.6 out of 18 (14%). Class performance on recall and problem-solving items for the first year and subsequent years of the project are given in Table 1. Summary data for instruction and evaluation are summarized in Table II. The design variables include the three variables manipulated and studied over the four year period. The response variables are recall and problem solving scores for the four final exams.

In the second year, a problem-solving laboratory was designed in which students were presented with clinical cases, observed slides under the microscope, saw culture plates and biochemical tests, and then identified the infectious agents. The class was divided into six groups of fifteen, each of which was given a different causative agent. Each group came to a concensus and presented the findings to the class. The laboratory activities were not exclusively related to the evaluation system since the students could obtain the same factual information by reading texts or attending lectures.

Attendance at laboratory sessions was poor, but performance on problem-solving test items improved over the previous year. The class average was 56% correct of 39 problem-solving items.

The following year (1978), the laboratory was restructured so that each student was responsible for a series of five unknowns which represented common causative agents in disease. Six groups of fifteen students each worked with an instructor. The instructor presented students with a general discussion and monitored laboratory techniques. The procedure for laboratory included streaking out the specimen onto an appropriate medium, preparing and reading a gram stain of the specimen with faculty assistance and incubating the plates. The sputum and stool specimens were prestreaked and the students were expected to pick isolated colonies and work from these. After plate incubation, students were on their own.

A second modification for this course offering was the restructuring of the schedule for examinations. Previously, the examination schedule had consisted of two examinations based on course units and a comprehensive final, weighted toward the latter course units. The new schedule consisted of six examinations, each counting for 15% of the course grade. There was at least one problem-solving item on each examination. Performance on problem-solving items increased to a class average of 69% correct of 42 items on the final examination. The possible explanations which might be offered for this are individual accountability for laboratory assignments and course credit for solving laboratory unknowns and exposure to problem solving items on the five formative examinations. Even a ten percent weighing for the laboratory component of the course appeared to be sufficient to increase student commitment to laboratory sessions.

During the 1979 academic year, the laboratory activities remained unchanged but the number of examinations was reduced to three. This change was instituted because other course directors were concerned that the number of examinations in microbiology was diverting student attention from other courses. The outcome for this most recent delivery of the course was that laboratory attendance remained high and student satisfaction with the course was high as the previous year as indicated by student evaluations of the course. The class average declined for problem-solving items from 69% to 66%, but this difference was not statistically significant ($p>.05$).

Results

Four variables were explored; prior educational performance, number of laboratory hours, credit for laboratory activities, and exposure to problem-solving examination items. Data on two measures describing student performance are summarized in Table III. Since the investigators were interested in determining whether differences in microbiology achievement should be attributed to science aptitude and previous learning, science MCAT scores and undergraduate science grade point average were used. A pretest of microbiology concepts was introduced in 1978. The class averages for the 1978 and 1979 administrations of this test are also reported in Table III. Performance on this pretest was used to provide concurrent validity for the background knowledge assumed in lectures and laboratories.

One way-analysis of variance was used to determine if there was a difference in the entering class means for science MCAT and undergraduate science grade point average across the four years of the study. The statistical test revealed differences between the entering classes ($F=7.12$, 396 d.f., $p<.05$). This difference is of questionable validity due to the change in MCAT scoring and format between 1978 and 1979. This drop did not seem to

have any effect on the development of problem-solving skills in the revised medical microbiology course.

The three variables which were manipulated in this study were number of laboratory hours spent on problem-solving techniques, class credit awarded for completion of laboratory activities, and exposure to problem solving examination items. The exposure to problem solving items was considered to be a function of student experience with the clinical case format in which items were presented. Interviews with students revealed that students used practice items on learning exams to change study habits and the way in which they approached the labs. These two aspects of exposure to problem-solving could not be separated in the analysis, since it was performed ex post facto.

Analysis of the three variables manipulated in this study revealed the relationships shown in Table IV. The table shows that the correlations between the three variables ranged from .83 to .91. The high intercorrelations of these three variable present a problem for interpretation since correlations of this size indicate that the variables are collinear. Attempts to clarify the relationships among these variables was impossible in the study since they were manipulated by constraints on the students and instructors rather than on experimental design.

The correlations between the three independent variables (number of laboratory hours, learning examinations, laboratory credit) and scores on the problem solving items of the final exam ranged from .73 to .95. The highest correlation being with number of hours in the laboratory exercises. A regression analysis was performed to relate the independent (manipulated) variables to problem solving achievement. In the regression analysis, only the laboratory hours variable was used because of the multicollinearity of

the independent variables. The result of regression problem solving success on laboratory hours is:

% problem solving = 22 + 4 (laboratory hours)

This equation produced an $R^2 = .89$ with the standard error of the estimate being 10.

Increasing the number of laboratory hours appears to have a significant impact on problem solving achievement. This variable had a linear relationship to problem solving. Increasing the number of tests which provided experience with problem solving test items appears to have some effect on problem solving achievement, however, this effect cannot be distinguished from the one hour increase in laboratory exercise time. The drop in problem solving skill from 1978 to 1979 cannot be attributed to the number of tests since the drop in problem solving performance (69% to 66%) is not as large as the standard error of the test (3.22 items or 8%). The requirement which made laboratory activities mandatory by awarding course credit for solution of unknowns may also have some influence on problem-solving performance. No inference can be drawn concerning this variable since it is confounded with the increase in laboratory hours. The large increase in problem solving skills from 1976 to 1977 can be interpreted primarily as a result of the increase in lab time. In summary problem solving skills were primarily a function of hands-on problem solving work but there was some additional effect due to exposure to problem solving items.

One implication of this study is that explicit recognition of problem solving objectives can lead to significant improvement in instruction of these objectives. This lends support to the systematic approach advocated by most experts in curriculum development and attests to the value of faculty time and effort devoted to consideration of course objectives. The subsequent

design of instruction and evaluation methods for teaching and testing for these objectives can be effectively implimented to improve student achievement.

REFERENCES

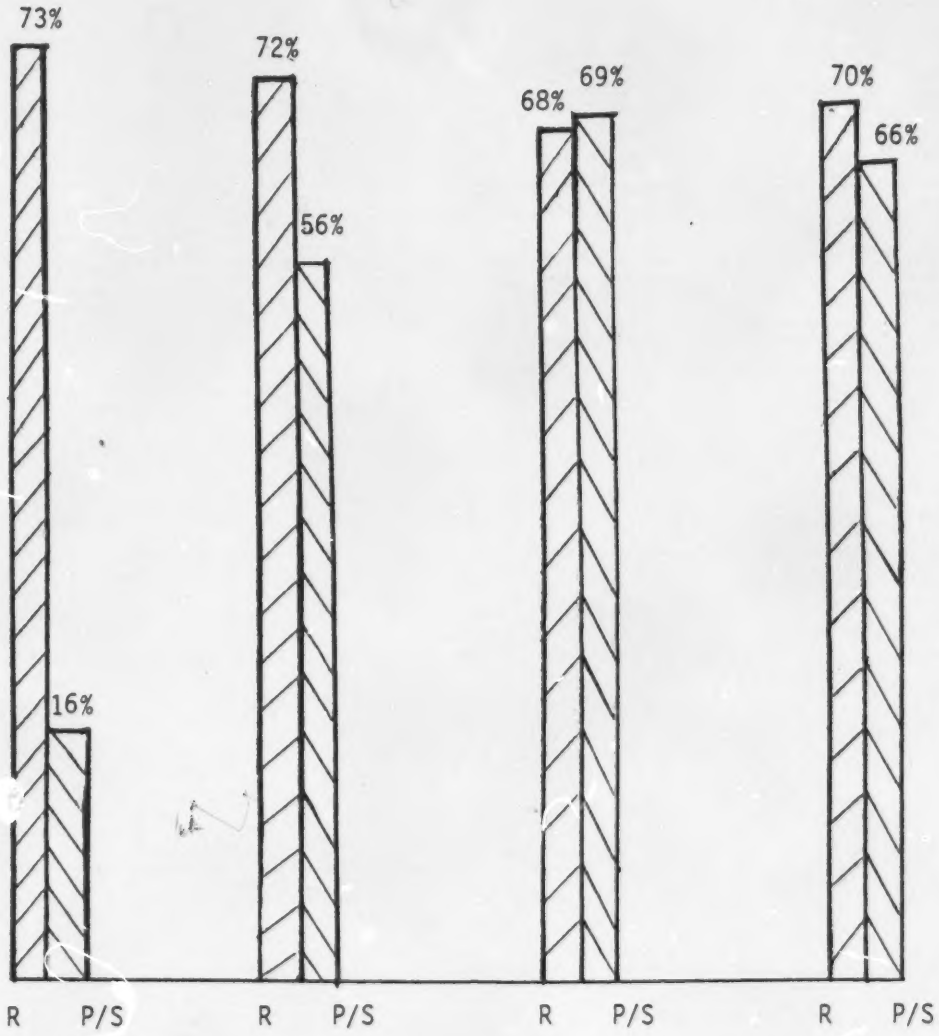
Gabridge, M.G. A Case for increased Emphasis on Medical Microbiology. ASM News, 40:462-464, 1974.

Gratzek, J.D. Microbiology in the Veterinary Medical Curriculum. ASM News, 39:670-672, 1973.

Myrvik, Q.N., Scott, L.V., Kazloff, L.M. and Briody, B.A. Medical Microbiology in North American Medical Schools: A Curriculum Survey, 1973-74. ASM News, 42:361-366, 1976.

TABLE I

MEAN PERCENTAGE OF RECALL (R) AND PROBLEM SOLVING (P/S) ITEMS CORRECT ON EXAMINATIONS ADMINISTERED IN FOUR YEARS



	1976	1977	1978	1979
N of R items	119	87	71	50
N of P/S items	18	39	42	42

TABLE II

SUMMARY OF INSTRUCTIONAL METHODS AND COURSE ACHIEVEMENT

	DESIGN VARIABLES			RESPONSE VARIABLES	
Year	Lab Hours	Mandatory/ Not Mandatory	# of Exams with Problems Solving Items	Final Exam Recall	Final Exam P/S
76	0	0	0	73%	16%
77	6	0	1	72%	56%
78	12	1	6	68%	69%
79	13	1	3	70%	66%

TABLE III

Entering Student Characteristics

	76	77	78	79
MCAT Science	599	583	606	545*
Science GPA	3.41	3.14	3.28	3.33
Micro Pre-test (mean percent correct)	NA	NA	42%	39%

*New MCAT Converted to standard scores

TABLE IV

CORRELATION MATRIX AND REGRESSION ANALYSIS

Problem Solving	Tests	Lab Hours	Lab Credit	
1				Problem Solving
.775	1			Tests
.945	.827	1		Laboratory Hours
.734	.873	.911	1	Laboratory Credit

Problem Solving = 22 + 4 (hours in lab)

R^2 = 89% S.E.E. = 10
S.E.E. (b) = .9

CASE PRESENTATION:

A 40 year old male chronic alcoholic was hospitalized in January, 1976 with the complaint of left pleuritic chest pain of four days duration accompanied by sweats, several hard "teeth-clattering" rigors, and a cough productive of bloody looking sputum.

A sputum and throat washings specimen were obtained and delivered to the laboratory for gram stain and culture. Three blood cultures from different sites were obtained and sent to the laboratory. A blood sample was sent to Virology for serology.

Laboratory results on sputum and throat washings:

Bacteriology:	few coagulase (+) staphylococci	
	Neisseria sp.	
	S. pneumoniae (few)	
	few gram negative rods	
	heavy alpha strep (S. viridans)	
Virology:	hemagglutinating virus isolated, identification to follow	
Serology:	Anti-influenza A	1:128
	Anti-influenza B	1:10
	Anti-parainfluenza	1:32
	Anti RSV	1:16
	Anti-adenovirus	1:10

7. Which of the findings would indicate the most probable cause for concern:

   A. coagulase (+) staphylococci
   B. Neisseria sp.
   C. S. viridans
   D. diphtheroids
   E. None of the above

8. The virology report indicates an antibody titer of 1:128 for Influenza A. The most reasonable conclusion at this point would be:

   A. the patient has contracted pneumonia
   B. the patient is suffering from Influenza A
   C. the patient has had Influenza B in the past
   D. B and C
   E. A and B

9. To confirm your answer, you would require

   A. Virus identification
   B. Convalescent serum
   C. isolation of S. pneumoniae
   D. A and B
   E. A, B and C

10. For identification of S. viridans the laboratory would have:

   A. observed gram (+) cocci in chains
   B. found these were resistant to optochin
   C. found these were sensitive to optochin
   D. A and B
   E. A and C

CASE PRESENTATION

A 29-year-old gravida 2, para 1 woman who was in the second trimester of her pregnancy suddenly experienced severe right flank pain. The patient also experienced increased frequency of urination, but no other urinary symptoms. Eight years previously, this woman had a symptomatic urinary tract infection caused by Escherichia coli that was attributed to cystitis (infection in lower urinary tract) although no definitive studies were performed to identify the source of infection. During that illness, the patient sustained an ampicillin reaction manifested by uticaria and moderate facial edema. A clean voided urine specimen was sent to the laboratory.

You will be provided with a urine sample. Using a 0.001 ml loop, plate the sample using the technique demonstrated on a blood agar and EMB plate. Incubate your plates overnight, then observe the plates and count the number of colonies. Keeping in mind the original dilution, calculate the number of organisms present in 1.0 ml of the specimen. Using colony morphology, gram stain and appropriate biochemical tests identify each organism present in your specimen. Record the results on your work sheets, make an evaluation of what the results of your specimen indicate in terms of the patient and describe what you will do next. Answer the study questions and turn in your work sheet and study questions before the next scheduled exercise. A demonstration of methods available for office urine culturing and methods of antibiotic sensitivity testing will be presented in the initial laboratory session.

1. The results of the specimen collected for the patient described are as follows:

   10,000 Proteus sp/ml
   10,000 Klebsiella pneumoniae/ml
   50,000 E. coli/ml

   Proteus - sensitive to ampicillin, gentamicin; resistant to gantricin

   K. pneumoniae - sensitive to ampicillin, gentamicin, gantricin

   E. coli - sensitive to ampicillin; resistant to gentamicin, gantricin

   How would you handle the patient?

2. The results of the specimen from the patient described are as follows:

   less than 10^5 S. aureus

   What would be your assessment of the results?